Biological Systems Engineering

Center for TMDL and Watershed Studies

Hardware River Bacteria TMDL Study (Updated: 11/30/2006)

Local Steering Committee Meeting

November 8, 2006

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General Watershed Characterization

Before beginning, it is important to note that this information provides a snapshot of the watershed characteristics at a given point in time. In order to complete the TMDL, we will need to know of any major changes (for example, the beginning or ending of a large agricultural operation, a major effort to install BMPs, or a large change in land use) that have occurred historically, so that we may accurately calibrate the watershed model, and predict future conditions. The map blow shows the Hardware River watershed boundaries with respect to Charlottesville and the County boundaries, along with the location of the watershed within the state (Figure 1).

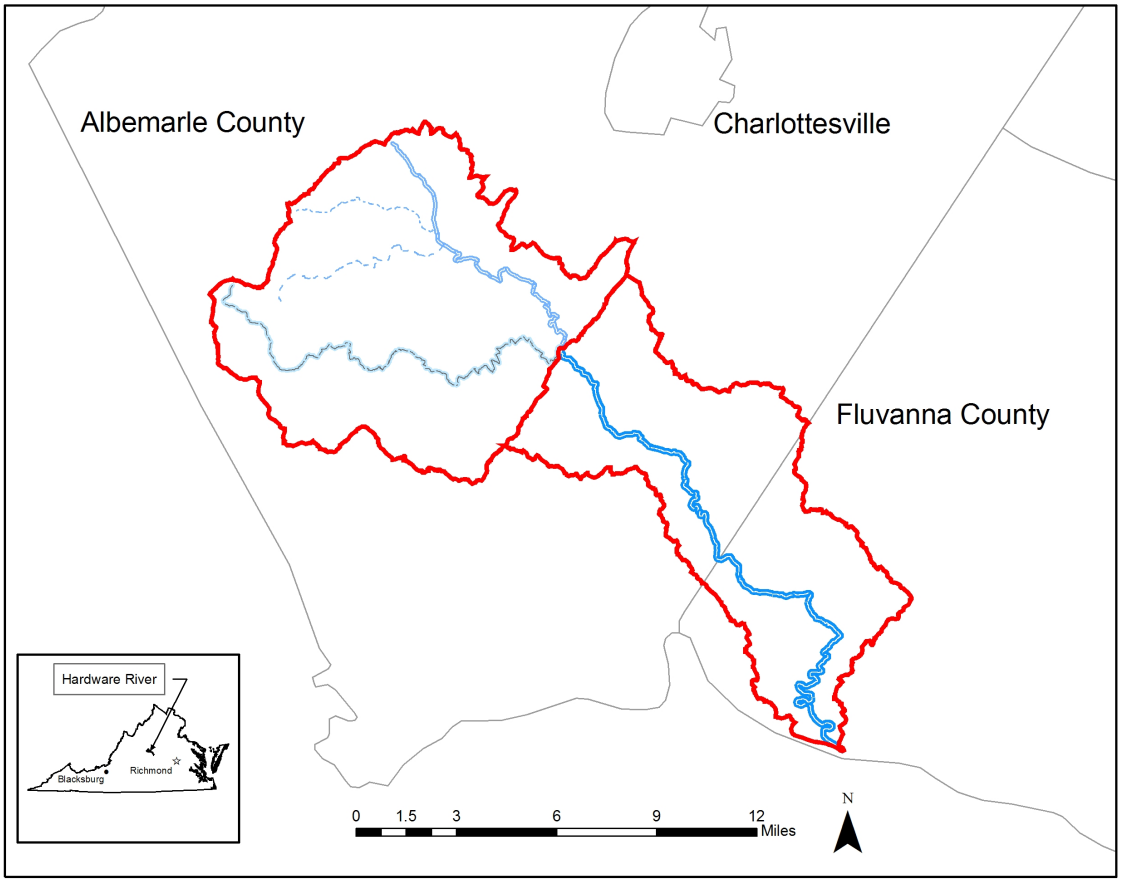


Figure 1. Hardware River Watershed Location.

Sub-watersheds

There are two bacteria impairments in the Hardware River watershed. One of the impairments is for the North Fork portion of the watershed and the other is for the remainder of the downstream watershed. For modeling purposes and to help in our discussion of the two impairments, we will refer to the two portions of the watershed with respect to the impairments as **North Fork Hardware River** and **Lower Hardware River**. The boundaries of the watersheds are shown in Figure 2. We use this naming convention to help organize the information in the remainder of this document.

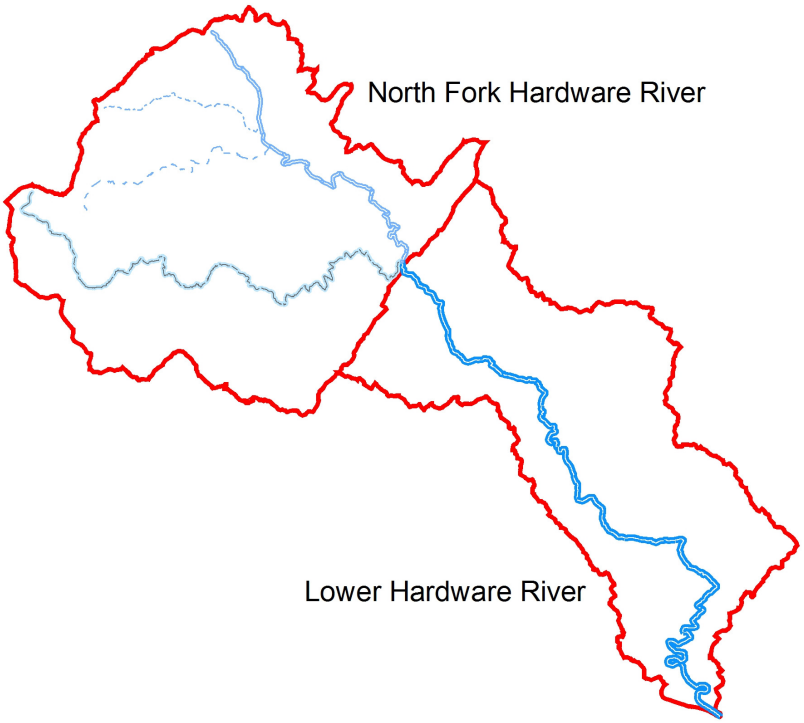


Figure 2. Hardware River Watersheds.

Sub-Watershed Division for North Fork Hardware River

For modeling and source characterization purposes, the watershed was sub-divided further into 25 sub-watersheds (Figure 3). The numbering of the sub-watersheds is from 0 to 24. These sub-watersheds will be the units used to organize the input data for modeling. The boundaries were made based on streams, land use patterns and other physiographic characteristics of the watershed.

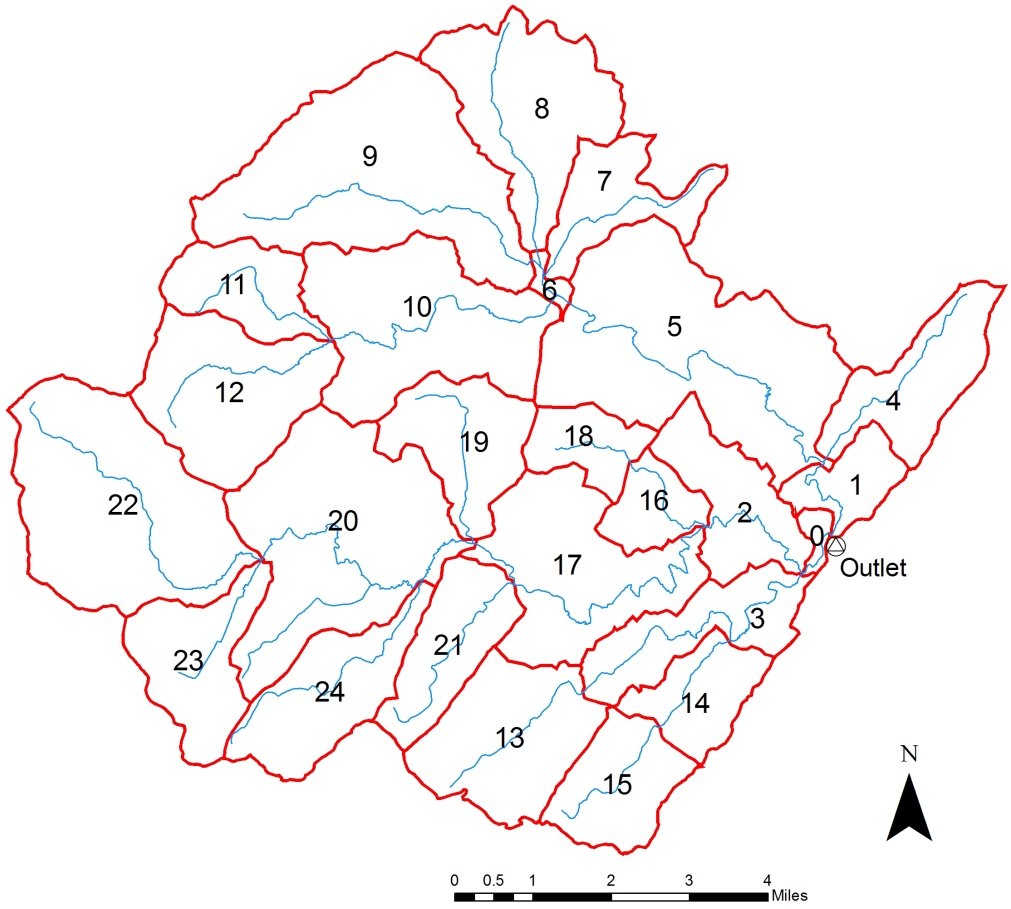


Figure 3. North Fork Hardware River Sub-Watersheds.

Sub-Watershed Division for Lower Hardware River

The Lower Hardware River watershed was sub-divided further into 24 sub-watersheds (Figure 4). The numbering of the sub-watersheds is from 0 to 23. These sub-watersheds will be the units used to organize the input for modeling. The boundaries were made based on streams, land use patterns and other physiographic characteristics of the watershed.

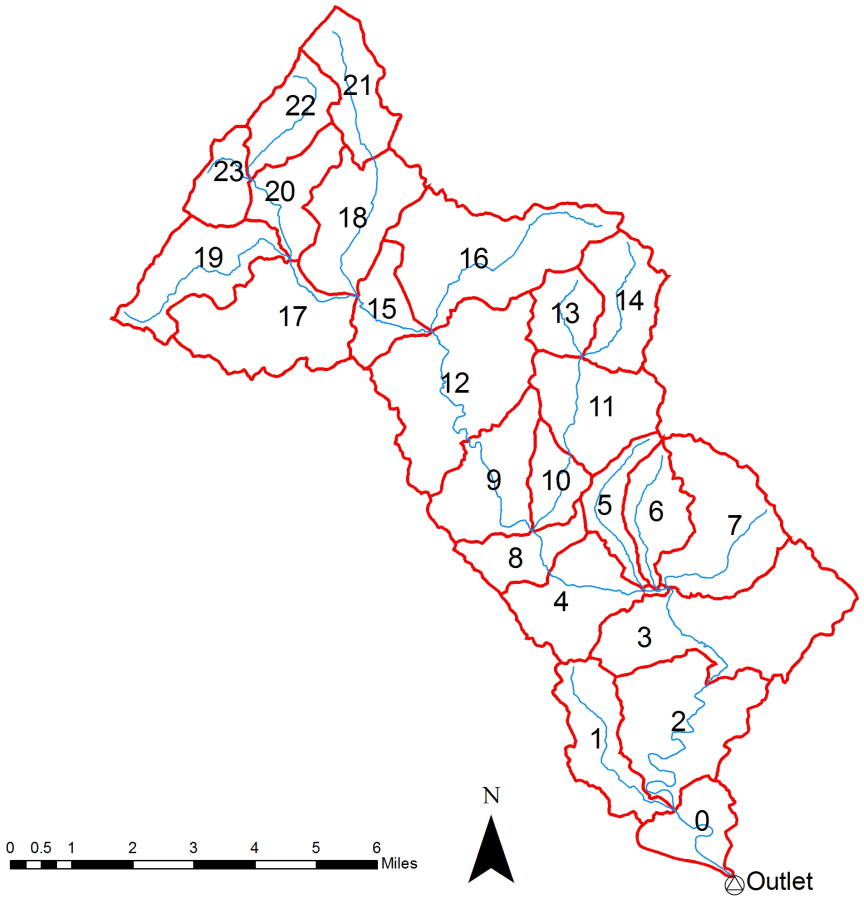


Figure 4. Lower Hardware River Sub-Watersheds.

Land Use

Land Use Estimate Methodology

Note: Based on discussion at the LSC meeting, the land use data was modified. Specifically, areas originally identified as cropland were compared to recent aerial imagery and reclassified when deemed necessary. The reclassified land use data is referred to as "Reclassified Land use" in the remainder of this document.

The National Land Cover Dataset (NLCD), available nationwide, was used to obtain the land use estimates. The NLCD is created based on interpretation of satellite imagery, and is a land cover dataset, not a land use dataset. Therefore, forested residential areas are put into the forest category, as the *cover* on that area is forest. Similarly, large park areas may be misinterpreted as pasture, because from the satellite interpretation, a large grassy area appears to be a pasture. Misinterpretation is more common in developed areas, but if there are any serious discrepancies we need to know. *The detailed NLCD land cover groups have been grouped into the 6 main categories in the table.* The percentages of the grouped land uses (original and reclassified) are in Table 1 and 2. The distribution of the original and reclassified land uses are shown in Figures 5 through 8.

Note: The reclassified land use has not been broken down by sub-wartershed yet. This is why only the totals are reported.

How the Land Use information is used

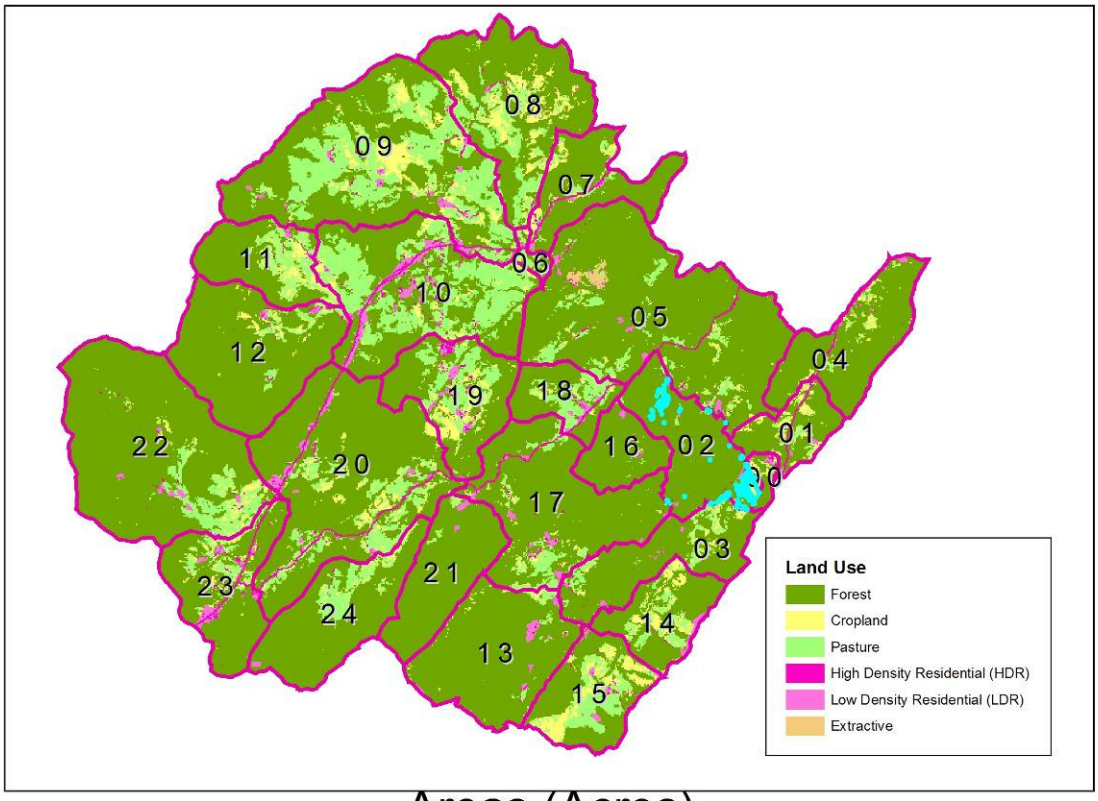
Land uses help distribute bacteria loads from various creatures to appropriate areas within the watershed. Land uses also aid in the estimation of certain animal populations. The bacteria TMDL will use the 'total pasture and hay' and 'total cropland' estimates from the table. The land use distributions are shown in Figure 5 through 8 on the following pages.

Table 1. Original Land use percentages for North Fork and Lower Hardware River Watersheds.

Watershed	Cropland	Extractive	Forest	HDR	LDR	Pasture
North Fork Hardware River	5%	0.1%	77%	1%	2%	14%
Lower Hardware River	8%	0%	78%	1%	1%	12%

Table 2. Reclassified Land use percentages for North Fork and Lower Hardware River Watersheds.

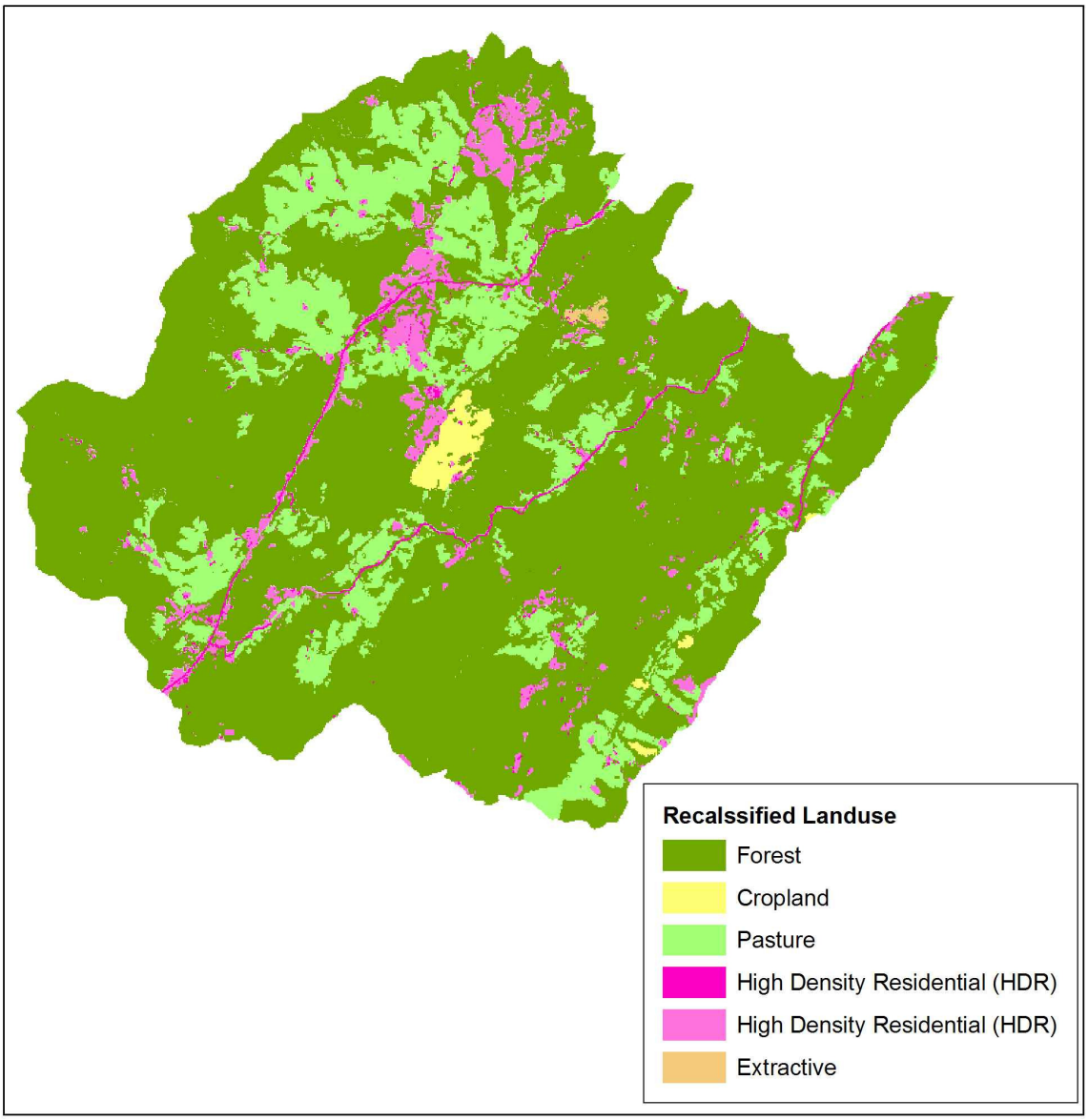
Watershed	Cropland	Extractive	Forest	HDR	LDR	Pasture
North Fork Hardware River	1%	<1%	77%	1%	5%	16%
Lower Hardware River	4%	0%	78%	1%	1%	16%



Areas (Acres)

Watershed ID	Cropland	Extractive	Forest	HDR	LDR	Pasture	Total
00	29		103	4	9	10	155
01	101		545	27	8	64	744
02	60		1,307	13	17	47	1,443
03	65		1,261	6	24	148	1,504
04	54		1,388	29	21	46	1,538
05	81	55.4	4,240	56	54	336	4,823
06	21		62	5	5	41	135
07	66		1,019	35	22	83	1,224
08	305		1,768	12	11	478	2,573
09	401		2,455	45	76	1,578	4,554
10	130		1,607	91	148	1,243	3,219
11	128		760	6	9	269	1,172
12	65		2,234	14	19	110	2,442
13	34		2,084	7	58	58	2,241
14	129		736	4	33	164	1,067
15	248		736	10	39	322	1,354
16	2		700	2	9	7	720
17	62		2,375	43	56	217	2,753
18	26		521	25	21	203	797
19	166	0.2	980	32	51	362	1,592
20	203		3,253	113	81	478	4,129
21	5		1,366	0	15	21	1,407
22	103	0.2	3,518	14	37	387	4,059
23	80		1,250	65	72	152	1,619
24	53		1,488	4	7	232	1,784
Total	**2,616**	**55.8**	**37,756**	**661**	**901**	**7,058**	**49,048**

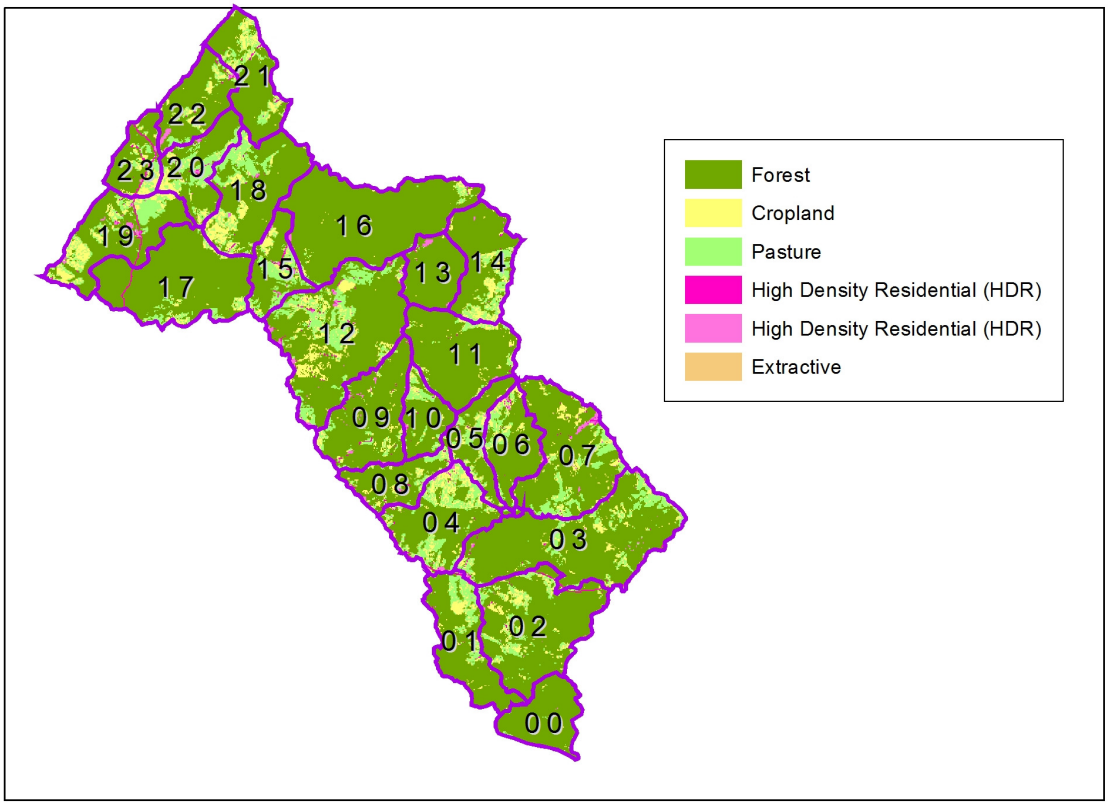
Figure 5. Land Use in the North Fork Hardware River Watershed.



Landuse Summary

Landuse	Cropland	Extractive	Forest	HDR	LDR	Pasture	Total
Area (ac.)	492	69	37,674	593	2,326	7,891	49,043
Percent of Total	1%	<1%	77%	1%	5%	16%	------
Percent Change	-81%	23%	0%	-10%	158%	12%	------

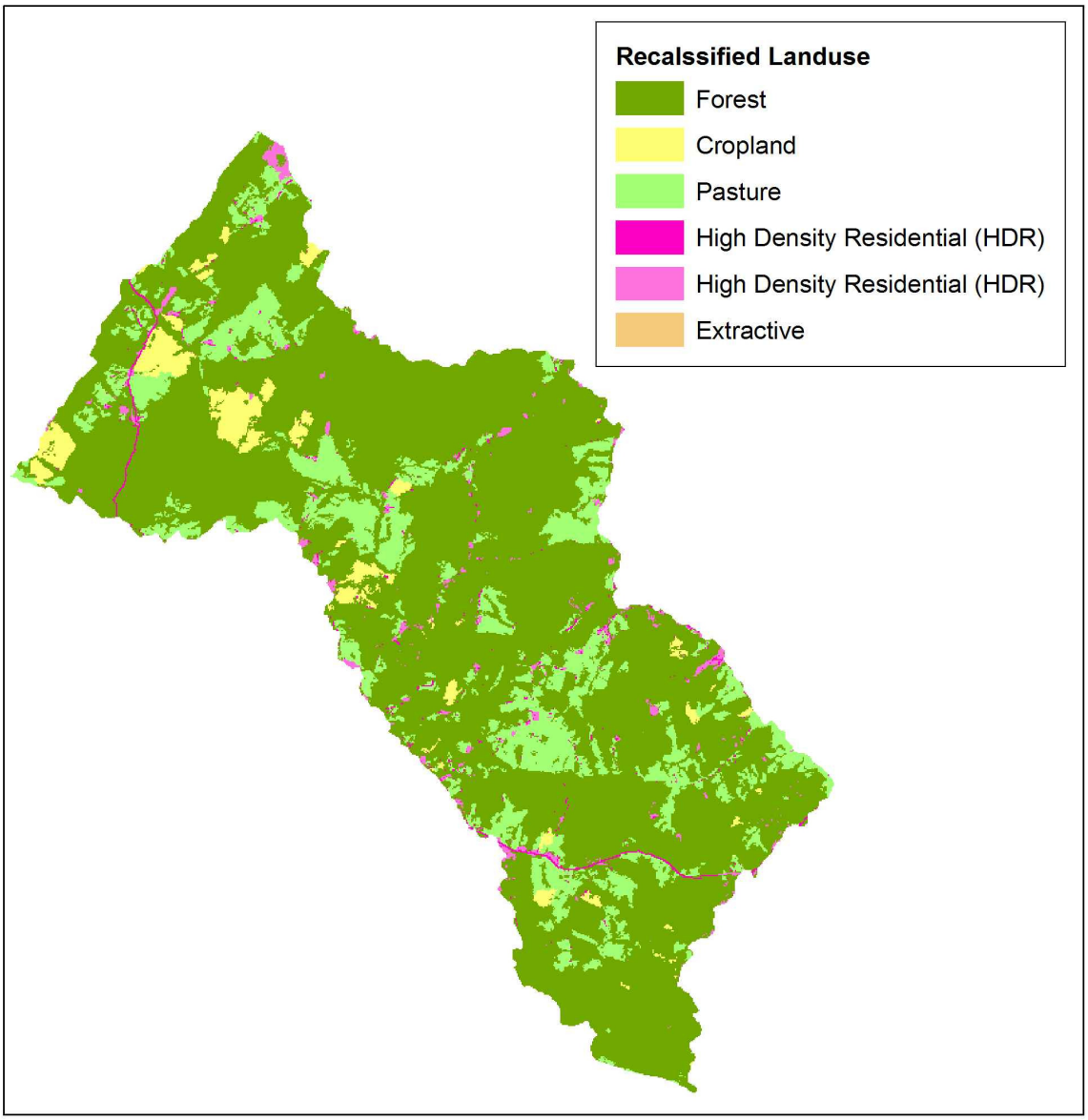
Figure 6. Reclassified Land Use in the North Fork Hardware River Watershed.



Areas (Acres)

Watershed	Cropland	Forest	HDR	LDR	Pasture	Total
00	5	953	0	0	18	976
01	105	1,134	13	10	198	1,459
02	187	2,039	35	6	244	2,511
03	180	2,733	34	19	350	3,317
04	261	998	28	34	368	1,689
05	101	532	13	9	150	805
06	96	760	10	16	156	1,038
07	183	1,748	21	51	272	2,275
08	77	667	14	18	109	885
09	79	1,502	18	30	103	1,732
10	50	551	7	9	107	724
11	77	1,632	7	6	84	1,806
12	344	2,272	33	63	584	3,296
13	5	841	3	14	8	871
14	163	1,008	3	12	190	1,376
15	102	514	15	12	245	888
16	42	2,981	5	19	60	3,107
17	79	2,222	16	0	149	2,466
18	236	1,280	9	15	339	1,878
19	251	1,091	30	43	300	1,716
20	123	643	10	13	286	1,075
21	146	952	9	2	160	1,270
22	87	867	8	28	104	1,093
23	103	507	32	9	110	761
Total	**3,082**	**30,428**	**372**	**438**	**4,692**	**39,012**

Figure 7. Land Use in the Lower Hardware River Watershed.



Landuse Summary

Landuse	Cropland	Forest	HDR	LDR	Pasture	Total
Area (ac.)	1,399	30,561	326	579	6,181	39,046
Percent of Total	4%	78%	1%	1%	16%	------
Percent Change	-55%	0%	-12%	32%	32%	------

Figure 8. Reclassified Land Use in the Lower Hardware River Watershed.

Livestock Numbers

Note: Animals numbers have not been updated for the reclassified land use yet. There were small changes in the pasture and forest areas, which will result in slight changes in the animal numbers. The current numbers provide very good estimates for discussion. The updated animal numbers will be available at the Hardware River TMDL Web Page: http://www.tmdl.bse.vt.edu/outreach/C105/.

Cattle

Dairy Cow Estimate Methodology

Confidence Level: Medium

The Virginia Department of Agriculture and Consumer Services (VDACS) provided a list of Grade A Dairy Farmers in Albemarle and Fluvanna Counties. The addresses of these dairies have been located. According to these locations, there are no dairies in the watersheds. If you know of any dairies that are not Grade A facilities, please let us know.

Table 3. Initial Estimates of Dairy Cow Population.

All Sub-watersheds	Dairies	Dairy Cows
Total	**0**	**0**

Beef Cattle Estimate Methodology:

Confidence Level: Medium

The Beef Cattle numbers were estimated using two different stocking densities. The first stocking density of 0.36 pairs per acre of pasture was used to estimate these numbers and is listed in Tables 3 and 4. This stocking density was developed based on information from extension agents and faculty at Virginia Tech and has been used in previous TMDLs. The second stocking density of 0.12 pairs per acre of pasture was estimated from the National Agricultural Statistics Service (NASS) of the USDA, which provides inventories of cattle on a county-wide basis. The county-wide numbers of beef cattle pairs and total pasture for Albemarle and Fluvanna Counties. We do not know of a database of beef producers, so local knowledge about the location of beef farms will be crucial in correctly estimating the beef cattle population. If there are a considerable number of stocker operations (as opposed to cow-calf operations), we need to know this.

Note: Based on watershed visits, we think that the lower cow/calf pair density of 0.12 pairs per acre that was estimated from the NASS data is more representative of beef operations in the Hardware River watershed.

Table 4. Initial Estimates of Beef Cattle Population in North Fork Hardware River.

Sub-watershed	Beef Cattle Pairs [a]	Beef Cattle Pairs [b]
00	4	1
01	23	7
02	17	5
03	53	17
04	17	5
05	121	39
06	15	5
07	30	10
08	172	55
09	568	183
10	447	144
11	97	31
12	40	13
13	21	7
14	59	19
15	116	37
16	3	1
17	78	25
18	73	24
19	130	42
20	172	55
21	8	2
22	139	45
23	55	18
24	84	27
Total	**2,541**	**818**

[a] Stocking density of 0.36 pairs per acre of pasture from previous TMDL plans
[b] Socking density of 0.12 pairs per acre of pasture from USDA National Agricultural Statistics Service data

Table 5. Initial Estimates of Beef Cattle Population in Lower Hardware River.

Sub-watershed	Beef Cattle Pairs [a]	Beef Cattle Pairs [b]
00	6	2
01	71	23
02	88	28
03	126	41
04	132	43
05	54	17
06	56	18
07	98	31
08	39	13
09	37	12
10	39	12
11	30	10
12	210	68
13	3	1
14	68	22
15	88	28
16	21	7
17	53	17
18	122	39
19	108	35
20	103	33
21	57	18
22	38	12
23	40	13
Total	**1,689**	**543**

[a] Stocking density of 0.36 pairs per acre of pasture from previous TMDL plans
[b] Socking density of 0.12 pairs per acre of pasture from USDA National Agricultural Statistics Service data

Dairy and Beef Cattle Numbers Use:

Manure from cattle can be directly deposited to the land surface (pasture or loafing lots), directly deposited to the stream (for pastures with stream access), or collected from animals in confinement. Manure collected in confinement is later spread on the land surface. Our methodology uses the application rates to calculate the amount of manure that is land-applied. The total manure produced is calculated as the product of the total number of cattle and their manure production rate; it is then apportioned to the aforementioned categories based on the percent of time the cattle spend in pastures, loafing lots, streams, and confinement.

Poultry

Poultry Number Estimate Methodology

Confidence Level: Medium

These numbers are taken from permitted poultry operations with greater than 20,000 chickens or 11,000 turkeys. Operations with fewer than birds than the number required for a permit are not likely to be significant sources of bacteria to the watershed. Potential issues with this information are historical changes (within the past 10 years) when large poultry operations may have gone in or out of business – these changes may affect our calibration. Based on these information sources there are no permitted poultry operations with greater than 20,000 chickens or 11,000 turkeys in the Hardware River Watershed.

Table 6. Initial Estimates of Poultry Numbers.

All Sub-watershed	Turkeys				Chickens	
	Hens	Toms	Brooders	Pullets	Pullets	Broilers
Total	0	0	0	0	0	0

Poultry Number Use

Poultry in operations >20,000 chickens or 11,000 turkeys are assumed to be confined all the time. Therefore, the poultry litter is assumed to be stored and land applied or sold at a later date. Poultry litter will be assumed to be land applied.

Manure Application Characteristics

We also could use some information on the average length of time storage facilities can handle manure in this watershed; the months of the year that manure is applied, and how much manure is applied each month (as a fraction of the total applied in a year), how often the manure is tilled-in, and what a typical rotation is for this area (i.e., for a 10 year rotation, how many years of corn, rye, hay, etc. are there?). Note while reading the table that the amount of manure actually applied to the land surface is limited to the amount of manure produced by confined animals in the watershed, and that cropland has priority to receive manure application. This means that if there is not enough manure produced in the watershed to meet the application rates for cropland, no manure will be applied to pasture.

Table 7. Potential Manure Application Rates to Cropland and Pasture/Hay Land Uses.

Type of Manure	Cropland	Pasture/Hay
Liquid Dairy (gal/ac-yr)	6,600	3,900
Solid/Semi-solid Cattle (lb/ac-yr)	24,000	24,000
Poultry Litter (lb/ac-yr)	6,000	6,000

Other Livestock

Other Livestock Estimate Methodology

Confidence Level: Low
The National Agricultural Statistics Service (NASS) of the USDA provides inventories of these groups of animals (among others) on a county-wide basis. The fraction of pasture area from each county present in each sub-watershed is multiplied by the total animal population for the county to make these estimates. These are quite uncertain estimates, as the animal populations in the NASS may come from 2 or 3 farms in a county that may not even be located in the Hardware River watershed. However, they are a good starting point for brainstorming.

Other Livestock Numbers Use

These animals are assumed to occupy pasture with minimal fecal contributions to the stream. Only the information for Horses was used. No information was available for pigs and ewes/goats in NASS (except for 8 pigs in Albemarle County). Any knowledge of any existing swine operations, large numbers of ewes/goats, or any other animal operations in the watershed will be useful in our treatment of these animal numbers.

Table 8. Initial Estimates of Other Livestock Populations for North Fork Hardware River.

Sub-watershed	Horses	Pigs	Ewes	Goats
00	1			
01	4			
02	3			
03	9			
04	3			
05	20			
06	2			
07	5			
08	28			
09	92			
10	72			
11	16			
12	6			
13	3			
14	10			
15	19			
16	0			
17	13			
18	12			
19	21			
20	28			
21	1			
22	22			
23	9			
24	13			
Total	**410**			

Table 9. Initial Estimates of Other Livestock Populations for Lower Hardware River.

Sub-watershed	Horses	Pigs	Ewes	Goats
00	1			
01	12			
02	14			
03	20			
04	21			
05	9			
06	9			
07	16			
08	6			
09	6			
10	6			
11	5			
12	34			
13	0			
14	11			
15	14			
16	3			
17	9			
18	20			
19	17			
20	17			
21	9			
22	6			
23	6			
Total	**273**			

Wildlife Populations

Note: Wildlife numbers have not been updated for the reclassified land use yet. There were small changes in the pasture and forest areas, which will result in slight changes in the wildlife numbers. The current numbers provide very good estimates for discussion. The updated wildlife numbers will be available at the Hardware River TMDL Web Page: http://www.tmdl.bse.vt.edu/outreach/C105/.

Wildlife Population Estimate Methodology

Confidence Level: Medium

The wildlife population estimates are obtained through an analysis of appropriate habitat area surrounding water bodies in the watershed. These estimates are based on habitat and population density estimates used in other TMDL watersheds and reported in the literature, harvest numbers from hunting, and include some adjustments we have made to create what we consider to be more reasonable estimates (Table 10). For deer and wild turkey, different animal densities were used based on different information (see footnotes at end of Table 10).

Note: The different animal densities for deer and wild turkey are presented for comparison and demonstrate the similarity of the animal density estimates that result from different information sources. These similar results increase our confidence in the estimate of these populations.

Table 10. Habitat and Population Density Estimates Used to Obtain Wildlife Numbers.

Wildlife type	Habitat	Population Density (animal/ac-habitat)
Deer	Entire Watershed	0.047 [a]
Deer	Entire Watershed	0.042 [b]
Raccoons	600 ft buffer around streams and impoundments	0.07
Muskrats	66 ft buffer around streams and impoundments in forest and cropland	2.75
Beavers	300 ft buffer streams and impoundments in forest and pasture	0.015
Geese	300 ft buffer around main streams	0.078 – off season 0.1092 – peak season
Wood Duck	300 ft buffer around main streams	0.0624 – off season 0.0936 – peak season
Wild Turkey	Entire Watershed except urban and farmstead	0.01 [c]
Wild Turkey	Entire Watershed except urban and farmstead	0.0043 [d]
Wild Turkey	Entire Watershed except urban and farmstead	0.0071 [e]

[a] Deer population density used in previous TMDL Plans from VADGIF information

[b] Deer population density developed from UVA wildlife study
[c] Wild Turkey population density used in previous TMDL Plans from VADGIF information
[d] Wild Turkey population density estimated from VADGIF 2005 Harvest information for Albemarle and Fluvanna Counties: estimated that 10% of the total population is harvested.
[e] Wild Turkey population density estimated from VADGIF 5-year average (2000-2005) Harvest information for Albemarle and Fluvanna Counties: estimated that 10% of the total population is harvested.

Wildlife Number Use

Wildlife are assumed to deposit feces on their appropriate habitat areas. Each type of wildlife is also assumed to spend a varying amount of time in the stream. The bacteria production rate for each type of wildlife is distributed to the stream and to the land surface based on the fraction of time spent in the stream and the appropriate land use breakdown.

Table 11. Initial Estimates of Wildlife Populations for North Fork Hardware River.

Sub-watershed	Deer [a]	Deer [b]	Raccoons	Muskrats	Beavers	Geese off season	Geese peak season	Wood Ducks off season	Wood Ducks peak season	Wild Turkeys [c]	Wild Turkeys [d]	Wild Turkeys [e]
00	7	6	0	1	1	4	6	3	5	1	0	1
01	35	31	1	1	1	8	11	7	10	7	3	5
02	68	61	1	1	2	12	16	9	14	14	6	10
03	71	63	1	2	5	27	38	22	32	15	7	11
04	72	64	2	2	3	17	24	14	21	15	7	11
05	227	203	3	3	6	32	45	26	39	47	22	33
06	6	5	0	6	1	5	7	4	6	1	0	1
07	58	52	2	2	2	17	23	13	20	12	6	9
08	121	108	1	13	3	19	26	15	22	26	12	18
09	214	191	3	26	4	26	36	21	31	44	20	31
10	151	135	7	14	4	22	31	18	27	30	14	21
11	55	49	0	14	2	15	21	12	18	12	6	9
12	115	103	1	7	3	17	24	14	20	24	11	17
13	105	94	1	0	3	14	20	11	17	22	10	16
14	50	45	1	3	1	9	12	7	10	10	5	7
15	64	57	1	11	2	12	17	9	14	13	6	9
16	34	30	0	0	2	9	13	8	11	7	3	5
17	129	115	3	2	5	30	42	24	36	27	12	19
18	37	33	2	3	1	7	9	5	8	8	4	6
19	75	67	2	12	2	15	21	12	18	15	7	11
20	194	173	7	15	6	38	54	31	46	39	18	28
21	66	59	0	0	3	17	23	13	20	14	6	10
22	191	171	1	14	5	28	39	22	34	40	18	28
23	76	68	4	2	2	12	17	10	14	15	7	11
24	84	75	0	11	4	22	31	18	26	18	8	13
Total	**2,305**	**2,060**	**44**	**165**	**73**	**434**	**606**	**348**	**519**	**476**	**219**	**338**

[a] Deer population density used in previous TMDL Plans from VADGIF information

[b] Deer population density developed from UVA wildlife study

[c] Wild Turkey population density used in previous TMDL Plans from VADGIF information

[d] Wild Turkey population density estimated from VADGIF 2005 Harvest information for Albemarle and Fluvanna Counties: estimated that 10% of the total population is harvested.

[e] Wild Turkey population density estimated from VADGIF 5-year average (2000-2005) Harvest information for Albemarle and Fluvanna Counties: estimated that 10% of the total population is harvested.

Table 12. Initial Estimates of Wildlife Populations for Lower Hardware River.

Sub-watershed	Deer[a]	Deer[b]	Raccoons	Muskrats	Beavers	Geese off season	Geese peak season	Wood Ducks off season	Wood Ducks peak season	Wild Turkeys[c]	Wild Turkeys[d]	Wild Turkeys[e]
00	46	41	0	1	2	11	16	9	14	10	5	7
01	69	62	1	0	4	20	27	16	23	14	6	10
02	118	105	2	5	5	26	36	21	31	25	12	18
03	156	139	2	1	2	13	18	10	16	33	15	23
04	79	71	2	0	2	12	16	9	14	16	7	11
05	38	34	1	1	3	18	25	14	21	8	4	6
06	49	44	1	2	3	14	20	11	17	10	5	7
07	107	96	2	4	3	14	20	12	17	22	10	16
08	42	38	1	0	1	5	6	4	5	9	4	6
09	81	72	1	0	3	14	19	11	16	17	8	12
10	34	30	0	0	2	9	12	7	10	7	3	5
11	85	76	0	0	2	10	14	8	12	18	8	13
12	155	139	3	3	3	15	21	12	18	32	15	23
13	41	37	0	0	2	9	12	7	11	9	4	6
14	65	58	0	0	3	14	20	11	17	14	6	10
15	42	38	1	1	2	9	12	7	10	9	4	6
16	146	130	1	1	5	24	33	19	28	31	14	22
17	116	104	1	0	2	8	12	7	10	24	11	17
18	88	79	1	3	3	15	20	12	17	19	9	13
19	81	72	2	3	4	22	30	17	26	16	7	11
20	51	46	1	0	2	9	13	7	11	11	5	8
21	60	54	0	3	2	13	19	11	16	13	6	9
22	51	46	1	4	2	14	19	11	17	11	5	8
23	36	32	2	0	1	6	8	5	7	7	3	5
Total	**1,836**	**1,641**	**26**	**32**	**63**	**324**	**448**	**258**	**384**	**385**	**177**	**273**

[a] Deer population density used in previous TMDL Plans from VADGIF information
[b] Deer population density developed from UVA wildlife study
[c] Wild Turkey population density used in previous TMDL Plans from VADGIF information
[d] Wild Turkey population density estimated from VADGIF 2005 Harvest information for Albemarle and Fluvanna Counties: estimated that 10% of the total population is harvested.
[e] Wild Turkey population density estimated from VADGIF 5-year average (2000-2005) Harvest information for Albemarle and Fluvanna Counties: estimated that 10% of the total population is harvested.

Human Population

Human Population Estimate Methodology

Confidence Level: Houses, High/Medium; Humans, Medium

Human population estimates are based on the US Census Block Group information. Block groups are smaller than counties, but still present a difficulty because they are not drawn on watershed lines. Human population estimates are based on the proportion of a sub-watershed's area that lies in a particular block group. As with the estimates of livestock from the agricultural census, this number can be skewed if there is a large population area in a block group that does not lie within the watershed boundary.

The age of houses was also estimated based on the US Census Block Group information. The age categories available from the Census are Pre-1969, 1970 to 1989, and post 1989. This method may be less accurate for new houses. However, new houses do not contribute as much bacteria as older homes, so their exact number is less crucial to pin down. The number of straight pipes was estimated from the Census data for houses "Lacking complete plumbing facilities". One 'unit pet' is assumed to occupy every house. This is equivalent to one dog or several cats. Acknowledging that many people do not have pets and several people have many pets, this averages out to an accurate estimation in most watersheds.

Human Number Use

Where sewer networks exist, the bacteria from humans is not considered as a nonpoint source load, but is instead represented by the effluent from a sewage treatment plant. To the best of our knowledge, there is not a sewer network in the areas of consideration for the Hardware River watershed. In this case, all the houses fall into the 'unsewered' category. Of these unsewered houses, any houses "Lacking complete plumbing facilities" from the Census data have the potential to discharge sewage directly to the stream via a straight pipe. All sewage produced by humans occupying these houses is assumed to be directly deposited in the stream. This increases the bacteria, nutrient, and organic matter content of the stream. The remaining houses are assumed to have septic systems. The septic system failure rates were based on house age: 20% for Pre-1969, 5% for 1970 to 1989, and 1% for post 1989. These failure rates have been used in previous TMDLs and were developed based on input from septic system pump-outs and best professional judgment. For failing septic systems, sewage may rise to the land surface. This becomes a load to residential land surfaces. Bacteria from pet feces is also a load to residential land surfaces.

Table 13. Initial Estimates of Human Population Information for North Fork Hardware River.

Sub-watershed	Population	Pets	Total Housing Units	Housing Units Pre-1969	Housing Units '70-'89	Housing Units Post-1989	Septic System Failures	Straight Pipes
00	8	3	3	1	2	0	0	0
01	50	21	21	10	9	2	2	0
02	65	26	26	7	15	5	2	0
03	67	27	27	7	15	5	2	0
04	104	43	43	20	19	5	5	1
05	358	147	147	55	54	38	14	3
06	10	4	4	1	1	1	0	0
07	124	51	51	13	15	23	3	1
08	238	98	98	27	30	41	7	1
09	275	113	113	44	41	27	11	2
10	194	79	79	31	28	19	8	2
11	71	29	29	12	11	7	3	1
12	147	60	60	24	22	15	6	1
13	98	41	41	19	15	7	5	1
14	51	22	22	8	10	3	2	0
15	76	34	34	20	12	2	5	1
16	32	13	13	3	7	2	1	0
17	128	52	52	17	25	10	5	1
18	45	18	18	7	7	4	2	0
19	96	39	39	15	14	10	4	1
20	234	96	96	39	35	22	10	2
21	61	26	26	12	9	4	3	1
22	231	94	94	38	34	22	10	2
23	77	32	32	14	12	6	3	1
24	78	33	33	15	12	6	4	1
Total	**2,916**	**1,200**	**1,200**	**459**	**454**	**286**	**116**	**23**

Table 14. Initial Estimates of Human Population Information for Lower Hardware River.

Sub-watershed	Population	Pets	Total Housing Units	Housing Units Pre-1969	Housing Units '70-'89	Housing Units Post-1989	Septic System Failures	Straight Pipes
00	72	30	30	14	11	5	3	1
01	130	61	61	33	20	8	8	2
02	193	83	83	41	29	14	10	2
03	232	94	94	41	35	18	10	2
04	136	60	60	31	21	9	7	2
05	50	18	18	7	7	4	2	0
06	64	24	24	8	10	6	2	0
07	142	52	52	18	21	12	5	1
08	89	41	41	24	11	6	5	1
09	91	39	39	17	17	4	4	1
10	42	16	16	5	7	3	1	0
11	99	38	38	12	17	8	3	1
12	146	59	59	15	34	11	5	1
13	39	16	16	4	9	3	1	0
14	65	26	26	7	14	5	2	0
15	39	16	16	4	9	3	1	0
16	140	57	57	14	32	10	5	1
17	110	44	44	11	25	8	4	1
18	102	42	42	15	21	6	4	1
19	79	32	32	10	17	5	3	0
20	61	25	25	10	12	3	3	0
21	86	36	36	17	15	4	4	1
22	74	31	31	14	13	3	4	1
23	37	15	15	5	8	2	1	0
Total	**2,316**	**954**	**954**	**377**	**415**	**161**	**98**	**19**

Notes